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BRIEFER ARTICLES.

ARTIFICIAL PARASITISM: A PRELIMINARY NOTICE.

SOME years ago, in the course of an investigation suggested by PFEFFER to show that ordinary roots, as well as those of parasites, can penetrate living tissues, I succeeded in growing a pea (*Pisum sativum*) on a plant of horse-bean (*Vicia Faba*), at least so far that the pea blossomed and set seed.[1] At intervals since that time I have grown peas on plants of the same bean, with success varying according to the very unideal conditions under which I have experimented. Some of the results obtained seem worthy of publication now, although I have only begun a piece of work which I hope to carry on for years to come.

The main object of the investigation is to ascertain how an independent plant will behave when compelled to lead a parasitic or partially parasitic existence; what the changes, immediate, successive, and cumulative, may be in successive generations.

The method so far pursued is this. Pea seeds of "extra early" varieties, soaked in water for twenty-four hours, are placed, radicle downward, in bulb pots of fine sand, and allowed to germinate until the radicles are 1–2^{cm} long. The seeds are now ready for setting on the beans. These are plants of *Vicia Faba*, 30^{cm} or more tall, grown two or three in each pot. Care is taken to select for experiment only strong plants, although I cannot see that the peas injure the beans on which they grow. At a height of about 15^{cm} above the soil I cut a hole, with a taper-pointed, sharp, clean scalpel, in the stem of the bean, the hole being about as large as the radicle of the pea selected for mounting on the bean plant. Into this hole the radicle is gently pushed, passing into the cavity of the hollow stem, until the cotyledons are close against the stem. A strip of writing paper is now so wrapped about the stem and fastened with sealing wax as to form a conical mold. Into this plaster of Paris is poured until it all but covers the cotyledons. In this way the pea is held in place without interfering with the upward growth of the plumule. In dry weather the molds are made deep enough to hold a layer of wet saw-dust 1^{cm} or more deep over the plaster. This is unnecessary, however, in damp weather. When the pea-plants are 5^{cm}

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[1] PEIRCE, G. J., Das Eindringen von Wurzeln in lebendige Gewebe. Bot. Zeit. **52**: 169–176. 1894.

or so high, I take off the paper and plaster, cut off the cotyledons, and thus force the peas to draw all their water and mineral salts from the bean plants. This they do successfully.

By such a simple method as this I compel peas to live on bean-plants in essentially the same degree of parasitic dependence as that of Viscum or Phoradendron upon oaks. What are the results? These will be shown by extracts from my laboratory notes.

January 27, 1902. Peas set November 12 on beans and in dirt in same boxes began to bloom; one flower on a bean-pea, several on soil-peas. Great difference in size of plants, number and area of leaves, size of flower and of parts of flower, between bean-peas and soil-peas. Weather since November 12 dry and cold for the most part.

These plants were grown out of doors in a cold frame on the southwest side of the laboratory building. The frame was usually open from nine or ten o'clock until four or five daily, the hours of opening and closing depending mainly upon the temperature. The boxes used were shallow and the soil poor. The soil-peas were about half the size which the plants of the same variety would attain later in the season in rich soil of proper depth. The bean-pea plants were about one quarter to one half the size of the soil-pea plants growing in the same boxes, but were well proportioned and stocky.

From these plants I harvested a crop of ten good seeds from the bean-peas and ninety-three from the soil-peas. On the bean-peas there were only two or three peas in a pod, and the pods were small and rather thin, splitting normally when dry.

These pea-seeds I subsequently measured by vernier caliper. The air-dry, ripe seeds were not uniform in shape, and rather than take the largest diameter in each case I decided to measure through the same points, as nearly as possible, in each seed, viz., on a line bisecting the hilum at a right angle, holding the hilum toward my lefth and, the caliper being in my right. Of the bean-peas three were decidedly smaller than the rest.

Thickness of smallest bean-pea seed	5.25^{mm}
Thickness of largest bean-pea seed	6.95
Average thickness of 10 bean-pea seeds	6.31
Average thickness of 7 larger bean-pea seeds	6.66
Average thickness of 3 smaller bean-pea seeds	5.48

I measured similarly the 93 seeds, ripe and air-dry, which I had gathered from the pea-plants grown in the soil. Three of these peas were more than 8.00^{mm} in thickness, one was 5.12^{mm}. This last was smaller than any bean-pea. There were also fifteen among these soil-peas which were less than 6.00^{mm} in thickness. The average thickness of 93 soil-peas was 6.88^{mm}.

The weights, air-dry, of the bean-peas and soil-peas were

	Bean-peas	Soil-peas
Total weight	1.709^{gr}	20.111^{gr}
Mean weight	0.170	0.216
Largest weighed	0.227	0.337
Smallest weighed	0.090	0.119

Comparing these sizes and weights of the seeds with the sizes of the plants, we see that the individual seeds are much less reduced in size and weight by the enforced semi-parasitism of the parents than are the vegetative parts.

I subsequently soaked these seeds, the ten and the ninety-three, in separate dishes of tap-water, for twenty-four hours. The bean-peas then weighed 3.363^{gr}, the soil-peas 32.449^{gr}. The bean-peas, therefore, gained 1.967 times their weight, the soil-peas 1.613 times. From this it may be inferred that the bean-peas either were thinner skinned or contained more actively absorbing substances than the soil-peas. Which was the case I cannot tell.

The bean-peas were then placed (2:00 P.M., May 5, 1903) in wet sphagnum to root. On May 6, 4:00 P.M., good normal roots 1^{cm} long had been formed by six of these seeds. I mounted them, as before described, on potted plants of *Vicia Faba.* The following morning three more were set on the bean plants. I broke the root of one of the ten seedlings in mounting it, and therefore threw it aside. Thus I had, mounted on bean plants, nine seedlings of peas grown the previous year on bean plants. These seedling peas, therefore, had never been in contact with the soil. Nevertheless, in the tap-water and especially in the sphagnum there was a certain amount of "dirt." This could be avoided, and will be in future experiments.

During the succeeding weeks these peas grew into little plants, somewhat smaller than those of the preceding season, but well proportioned and healthy-looking. I moved them from the laboratory to my own garden, where they would be watered during the summer vacation and where I could watch them, but unfortunately a dog or some other creature played havoc with my beans one day while I was away from home, and my experiment was ended.

Something should be said, even in such a superficial account as this, about the roots of the peas grown on beans, and of the relations of these roots to the tissues of the beans. There was no tissue union between host and parasite as in natural semiparasites like Viscum and Phoradendron. The roots grew downward through the internodes and nodes, but did not, in any case here reported, reach the level of the soil, much less reach the soil itself. The roots branched much less freely than normal soil roots, were closely applied to the walls of the hollow internodes, and did not at any point fill the cavity of the internode.

That this much reduced root-system sufficiently supplied the small bean-pea plants with water is proved by an accidental experience. The potted bean plants one day became dry enough to wilt, but the peas were perfectly fresh and turgescent. The beans recovered promptly when watered and the peas at no time showed any ill effects.

It may be claimed that the smaller size of the pea-plants grown on beans is due to hard times—to mechanical interference with the normal growth and development of the root system. This may be true, but it is equally true that there are mechanical hindrances to the growth, extension, and development of the root systems of all phanerogamic parasites. In this respect, therefore, the cases are parallel.

In the aerial parts of Viscum, Phoradendron, and Arceuthobium,[2] xerophytic characters are evident.[3] These did not appear in my bean-peas, unless the smaller number and size of the leaves and the shortened internodes may be so called. Xerophytic characters may appear later if peas are cultivated on beans through a series of generations. I hope to be able to do this, under conditions which can be carefully controlled, and especially where my plants may at least be protected against ordinary accident.

I have tried various other seeds on *Vicia Faba*, including *Vicia Faba* itself, but peas have so far done best and *Vicia Faba* has proved to be the best host for them. A more succulent plant with solid stem, however, would be better. This I shall try in the future.

Though this is an incomplete account of experiments far from concluded, it has seemed best to put this much of my work on record. It may throw a little light on questions regarding the beginning of parasitism, the immediate effects of removing the roots of green plants from their normal medium, the soil, and compelling these green plants to supply themselves with water and mineral matters from other plants.—GEORGE J. PEIRCE, *Stanford University, California.*

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[2] I expect presently to publish a paper on Arceuthobium.

[3] CANNON, W. A., The anatomy of *Phoradendron villosum*. Bull. Torr. Bot. Club **28**: 374–390. *pls. 27–28.* 1901.